

Soil moisture retrieval from ALOS PALSAR in the Alzette (Luxembourg) and Zwalm (Belgium) catchments

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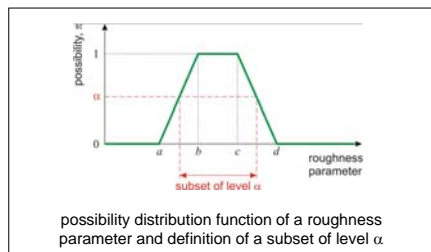
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Abstract: Synthetic Aperture Radar (SAR) has already shown its large potential for monitoring soil moisture fields from space at a high spatial resolution. However, the retrieval process is hampered with the uncertainty in soil roughness, a variable which plays a crucial role in the backscattering process. Based on field experiments in the Alzette catchment in Luxembourg and the Zwalm catchment in Belgium, performed simultaneously with ALOS PALSAR acquisitions, a recently introduced possibilistic retrieval algorithm (Verhoest et al., 2007) that accounts for uncertainty in soil roughness is validated. Field experiments included soil moisture sampling whereas the SAR imagery underwent standard processing techniques, including speckle filtering. Using the possibilistic retrieval technique, soil moisture values and corresponding uncertainty measures are obtained, which are validated against the ground truth data. Due to the larger sensitivity of the L-band sensor to soil roughness, it was found that ALOS data result in retrieved soil moisture values which are characterized by high uncertainties.

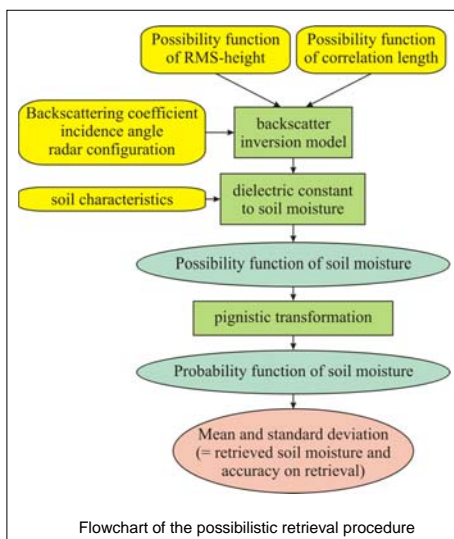
Methodology: Soil roughness is generally described by the root mean square (RMS) height s , the correlation length, l , and the autocorrelation function (ACF). Several studies have shown a large variability (and thus uncertainty) of s and l within one type of tillage. For agricultural fields, the ACF can be considered to be exponential (Callens et al., 2006). Uncertainty in the roughness parameters can be introduced through defining possibility distribution functions. Possibility theory is a mathematical tool which allows to deal with different types of uncertainty (Zadeh, 1978).

Based on the possibility distributions of the soil roughness, the possibility distribution of the soil moisture retrieved from a backscattered signal is calculated. Therefore, we introduce an α -cut ($0 \leq \alpha \leq 1$), which defines a subset of level α , for as well the RMS height as the correlation length



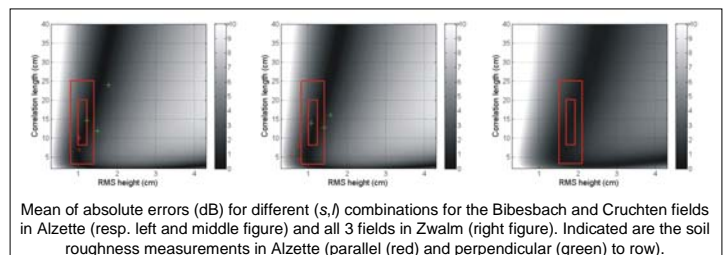
For an α , all combinations of the subsets for RMS and correlation length have to be used to invert the backscatter model (IEM, Fung, 1994) to a moisture content. The minimum and maximum soil moisture values are retained, defining the subset of level α for the retrieved soil moisture. This procedure has to be repeated for all α -values between 0 and 1, resulting in the possibility distribution function for the retrieved soil moisture.

Finally, the possibilities are converted to probabilities using a pignistic transformation (Dubois and Prade, 1982; Smets, 1990). From this probability distribution, the mean can be calculated and considered as the inverted soil moisture content while the standard deviation is an indication of the expected accuracy on the retrieved soil moisture content.

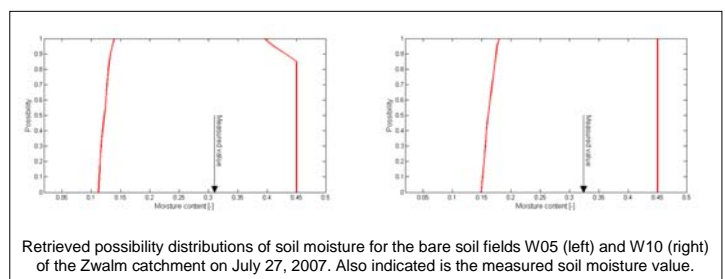


Experiment: Field averaged soil moisture was determined on two fields in the Alzette catchment and on three fields in the Zwalm. Only for the Alzette catchment, soil roughness was determined using a 4-m wide meshboard. Simultaneous with field campaigns, PALSAR HH images were acquired.

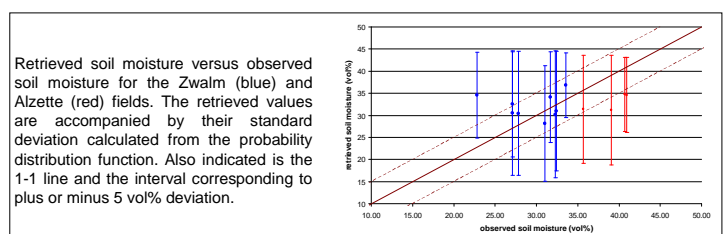
Field	date	crop	soil moisture (vol%) (0-5 cm)	average soil roughness (s,l)		backscattering coefficient (dB)
Alzette						
Bibesbach	19.02.08	none	35.70	(1.31 cm,13.46 cm)	(1.43 cm,22.15 cm)	-15.09
Bibesbach	19.03.08	none	40.71	(1.31 cm,13.46 cm)	(1.04 cm,4.70 cm)	-14.17
Cruchten	19.02.08	none	39.06	(1.03 cm,10.10 cm)	(1.35 cm,20.15 cm)	-15.04
Cruchten	19.03.08	none	40.91	(1.03 cm,10.10 cm)	(1.16 cm,3.05 cm)	-14.13
Zwalm						
W03	11.06.07	wheat	27.11	-	(1.78 cm,14.60 cm)	-12.68
W03	10.07.07	wheat	31.70	-	(1.81 cm,4.20 cm)	-11.49
W03	27.07.07	wheat	33.55	-	(2.00 cm,12.85 cm)	-10.90
W05	11.06.07	wheat	27.84	-	(1.70 cm,3.55 cm)	-12.38
W05	10.07.07	wheat	32.27	-	(1.67 cm,3.15 cm)	-12.46
W05	27.07.07	none	31.03	-	(1.84 cm,21.00 cm)	-12.98
W10	11.06.07	wheat	22.79	-	(2.00 cm,7.25 cm)	-11.35
W10	10.07.07	wheat	27.12	-	(1.69 cm,7.25 cm)	-11.91
W10	27.07.07	none	32.41	-	(1.71 cm,14.05 cm)	-12.42



Possibility distributions have been defined based on the obtained roughness parameters. The support and core have been indicated in above figures.



Results: Soil moisture gets retrieved with an overall RMSE of 5.36 vol%. However, estimated uncertainty (i.e. standard deviation on retrieved probability distribution function) is very high. An underestimation is obtained at nearly wet conditions (at Alzette). This can be attributed to the cut-off of retrieved soil moisture values at saturated moisture content. An overestimation may be observed for intermediately wet Zwalm fields. This can be attributed to the fact that both roughness parameters are considered to be independent causing unlikely parameter combinations that result in unreasonably high soil moisture contents.



- References:**
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